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(54) SEMICONDUCTOR DEVICE, SEMICONDUCTOR MODULE AND HARD DISK

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(52) **U.S. Cl.** **257/720**; 257/251; 257/712; 257/718; 257/719; 257/675; 257/796; 257/707; 438/122

(58) **Field of Search** 257/707, 711, 257/712, 720, 718, 719, 675, 796; 438/122

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(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

The back surface of a semiconductor chip **(16)** is exposed from the back surface of an insulating resin **(13)**, and a metal plate **(23)** is affixed to this semiconductor chip **(16)**. The back surface of this metal plate **(23)** and the back surface of a first supporting member **(11)** are substantially within a same plane, so that it is readily affixed to a second supporting member **(24)**. Accordingly, the heat generated by the semiconductor chip can be efficiently dissipated via the metal plate **(23)** and the second supporting member **(24)**.

7 Claims, 11 Drawing Sheets

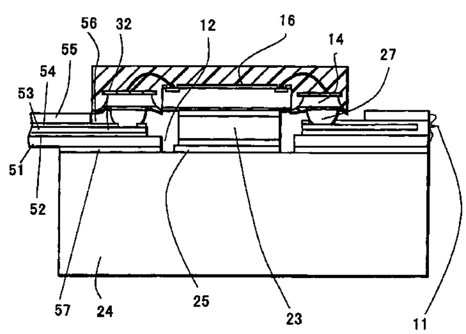


FIG.1A

FIG.1C

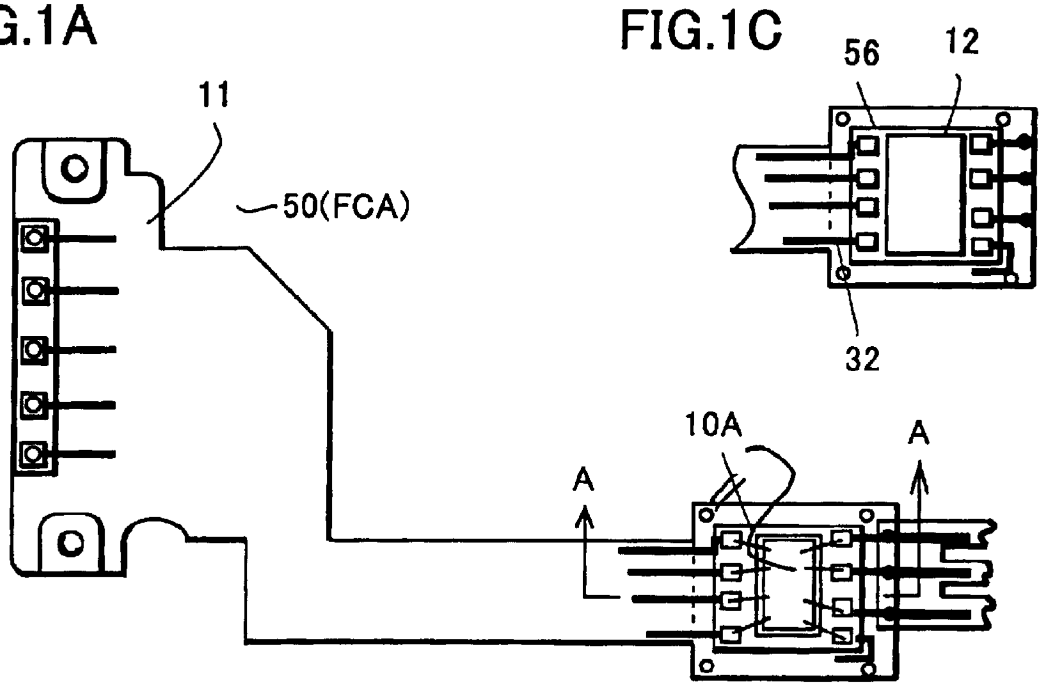


FIG.1B

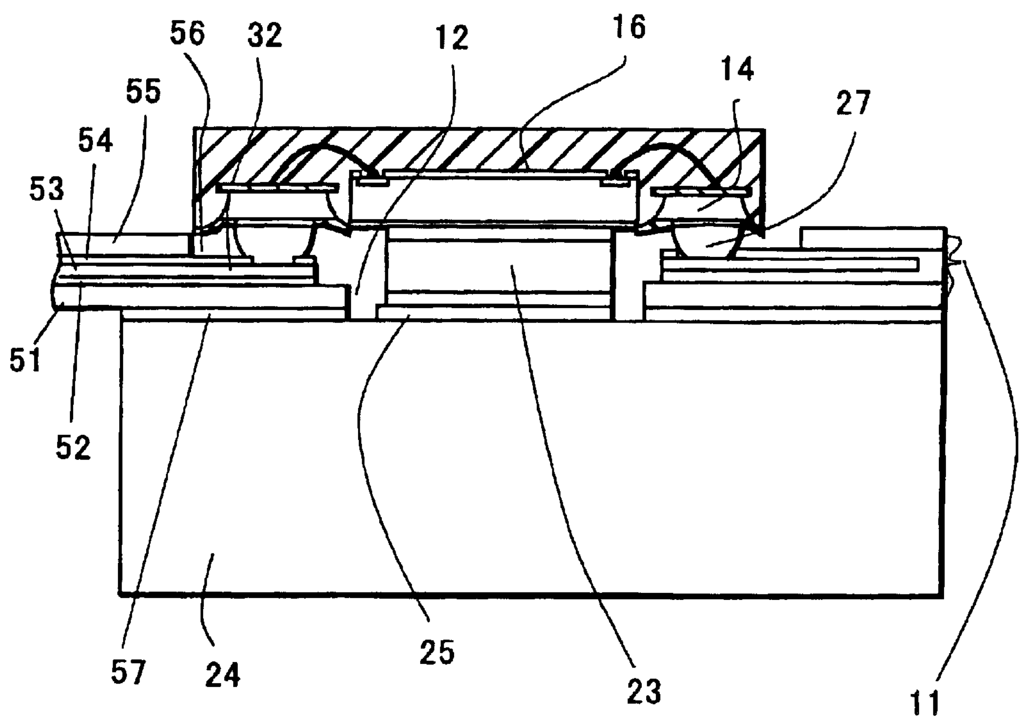


FIG.2A

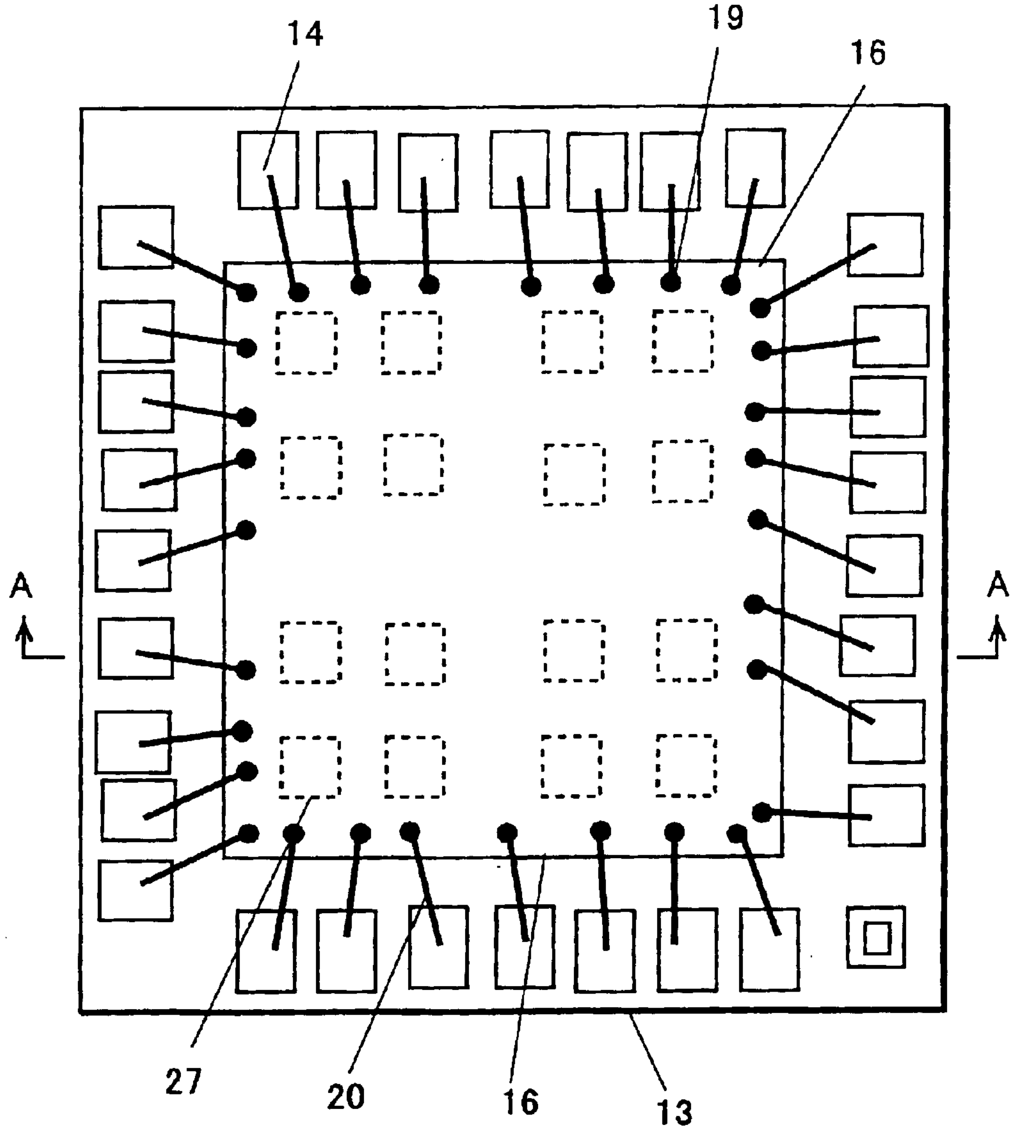


FIG.2B

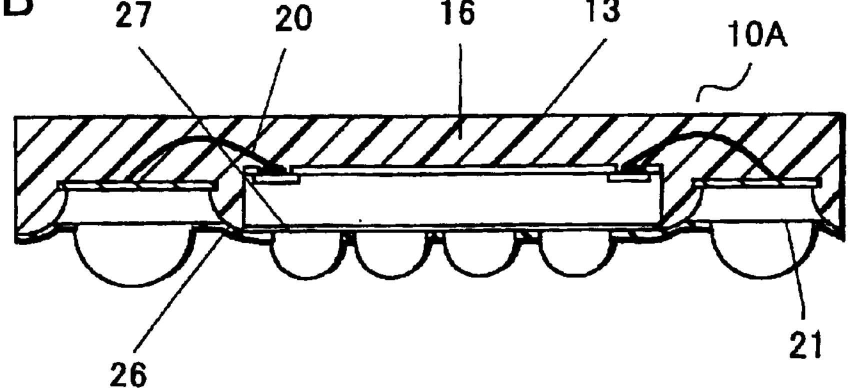


FIG.3A

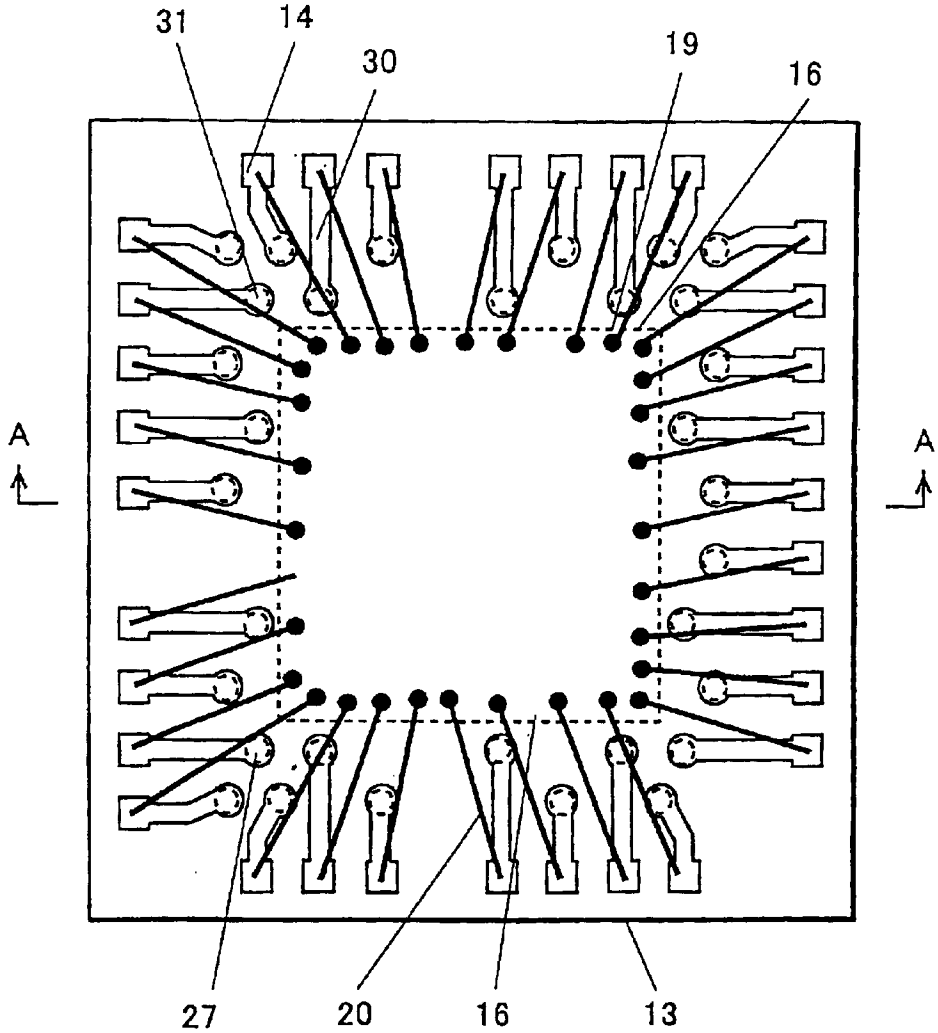


FIG.3B

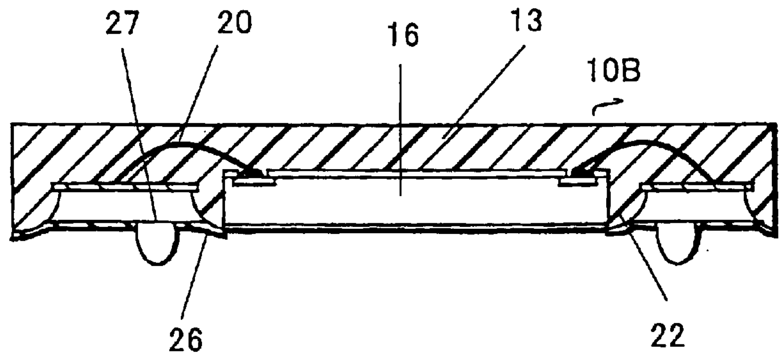


FIG.4

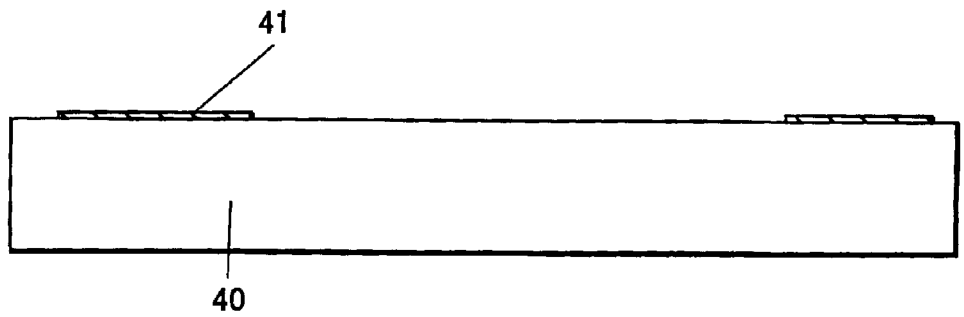


FIG.5

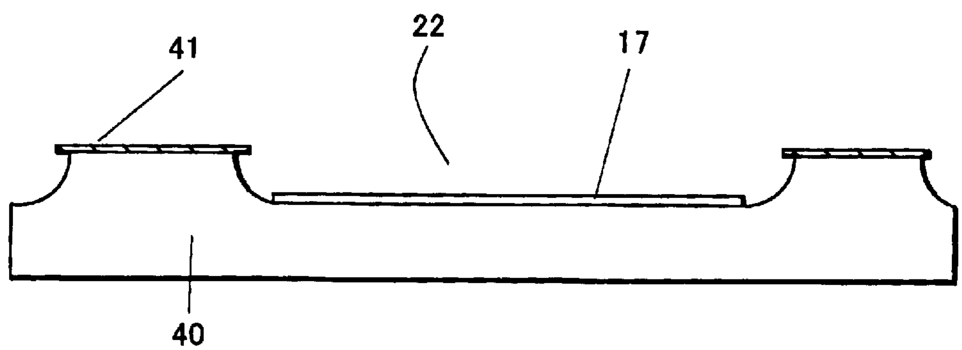


FIG.6

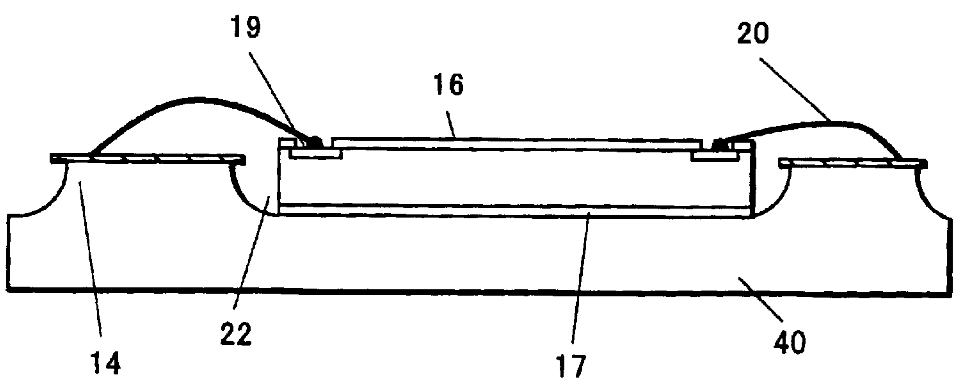


FIG.7

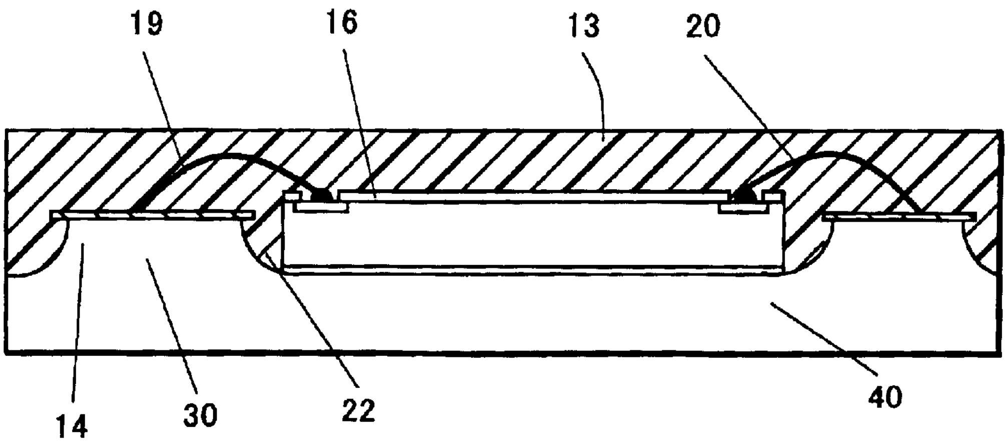


FIG.8

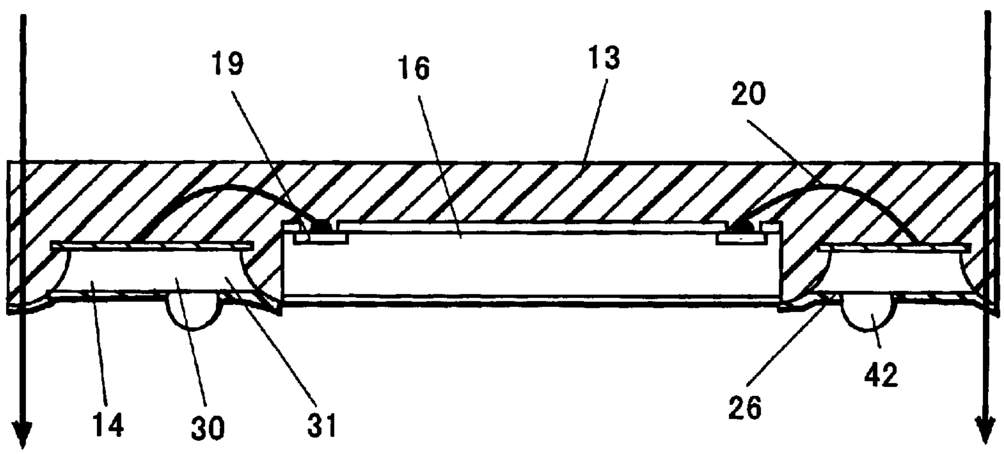


FIG.9

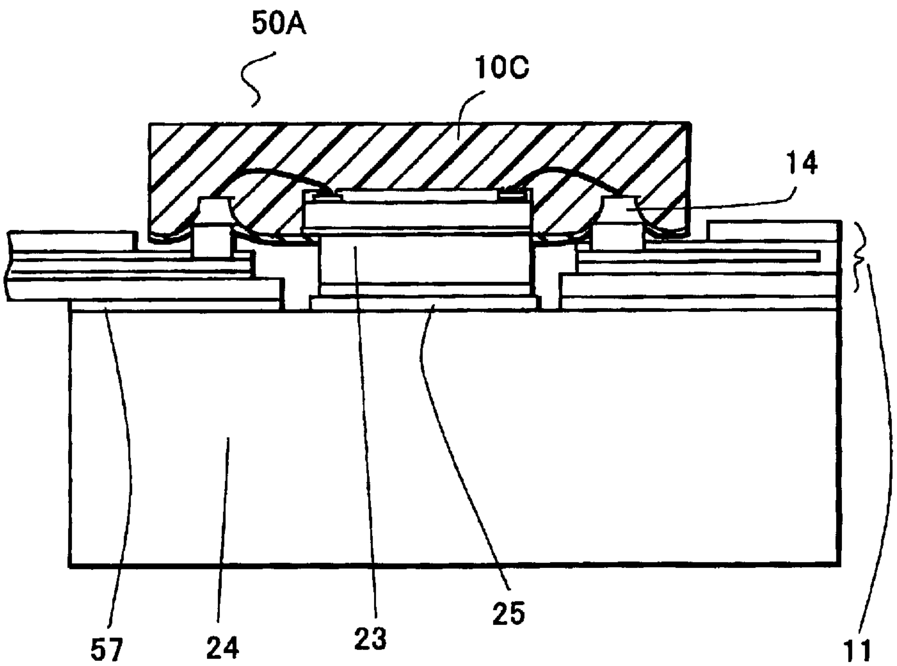


FIG.10

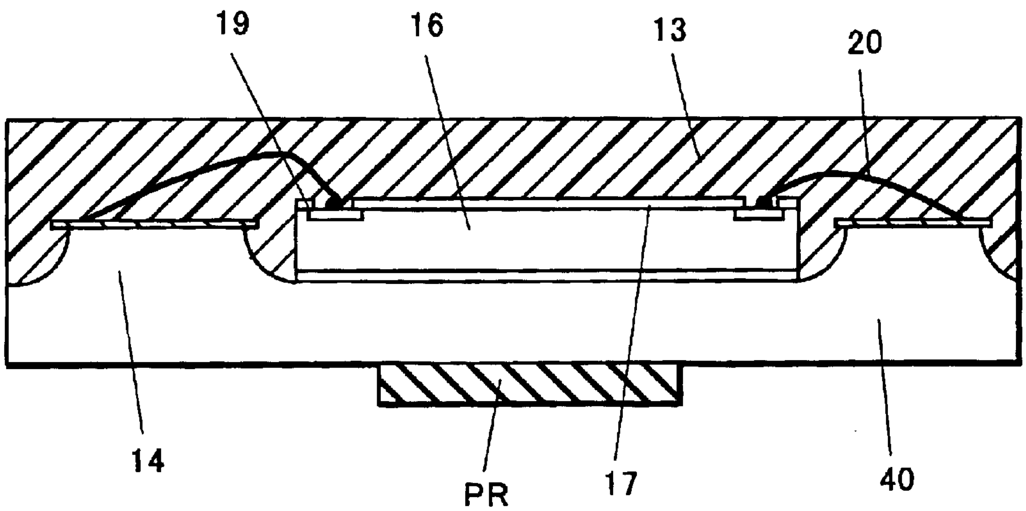


FIG.11

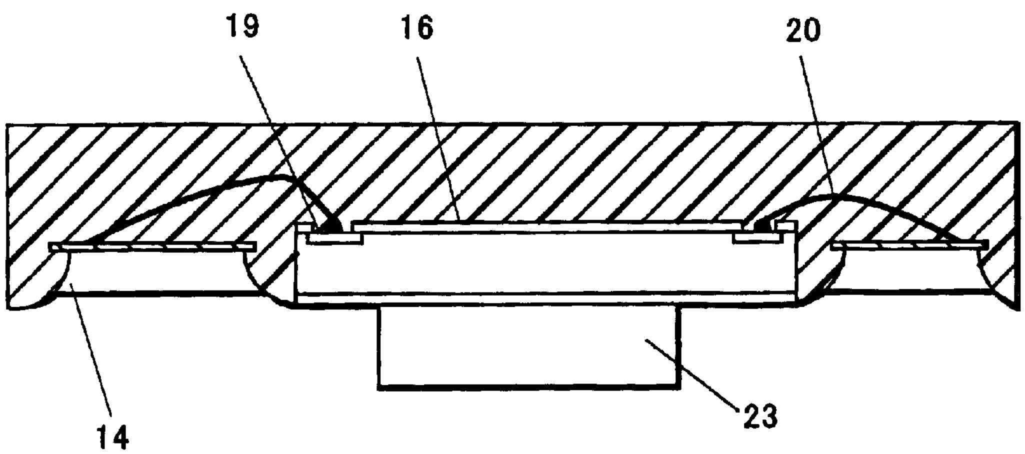


FIG.12

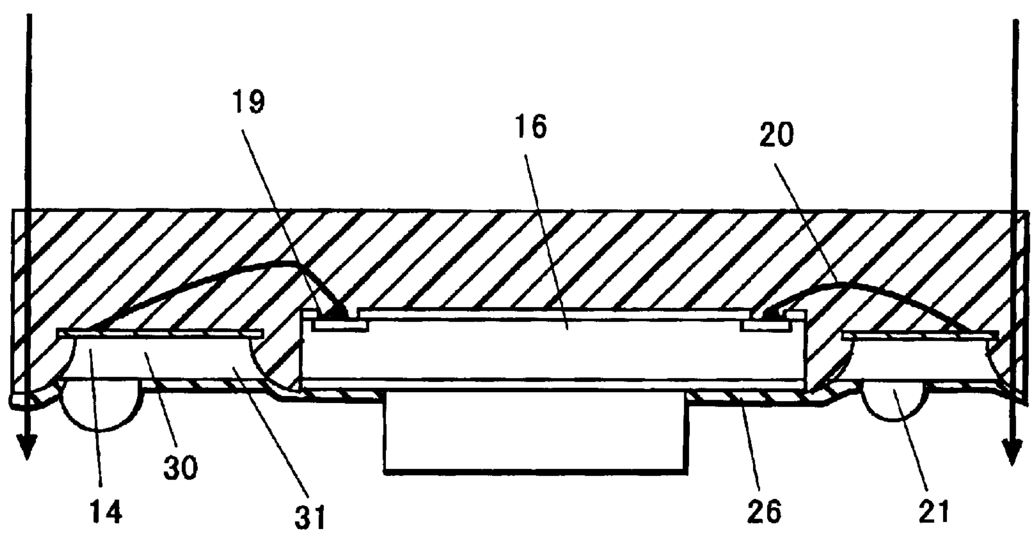


FIG.13A

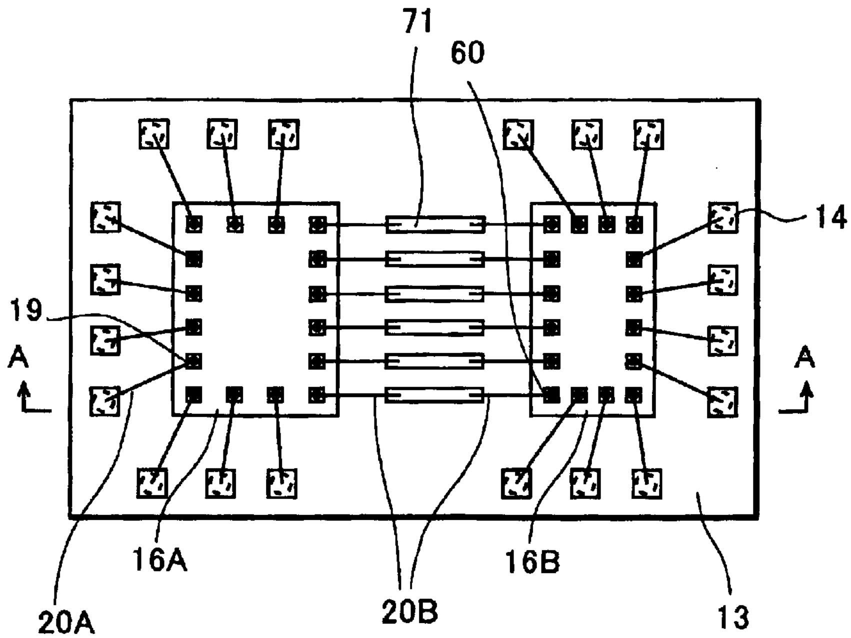


FIG.13B

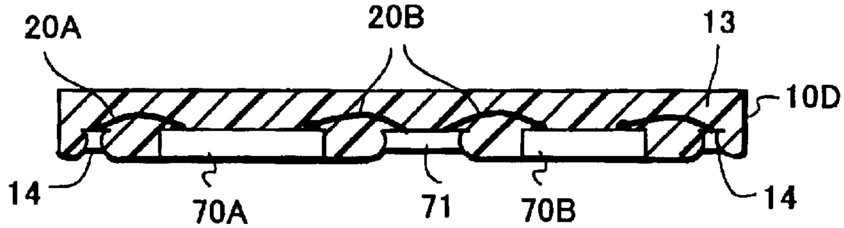


FIG.14

PRIOR ART

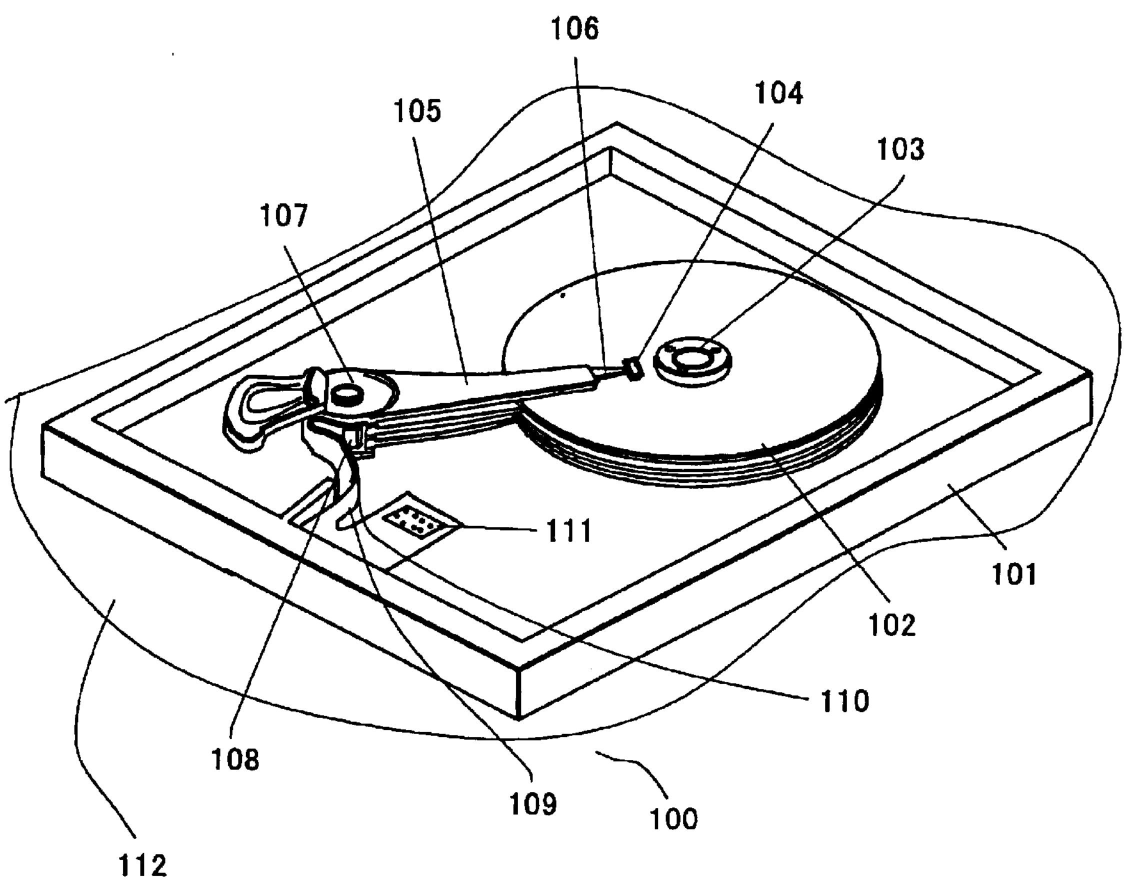


FIG.15A

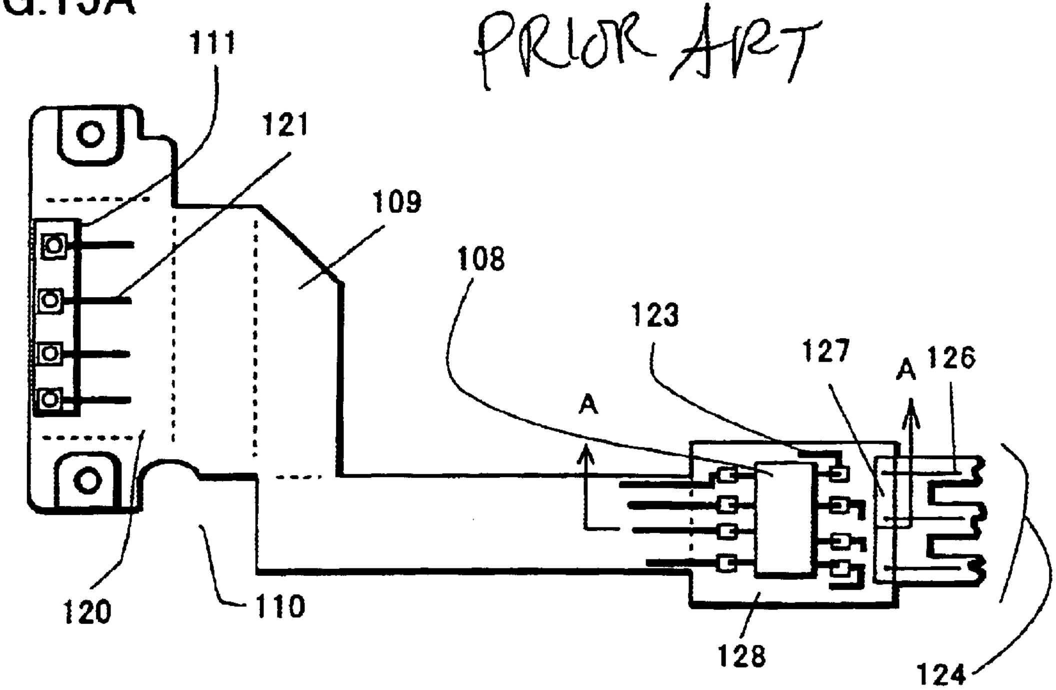
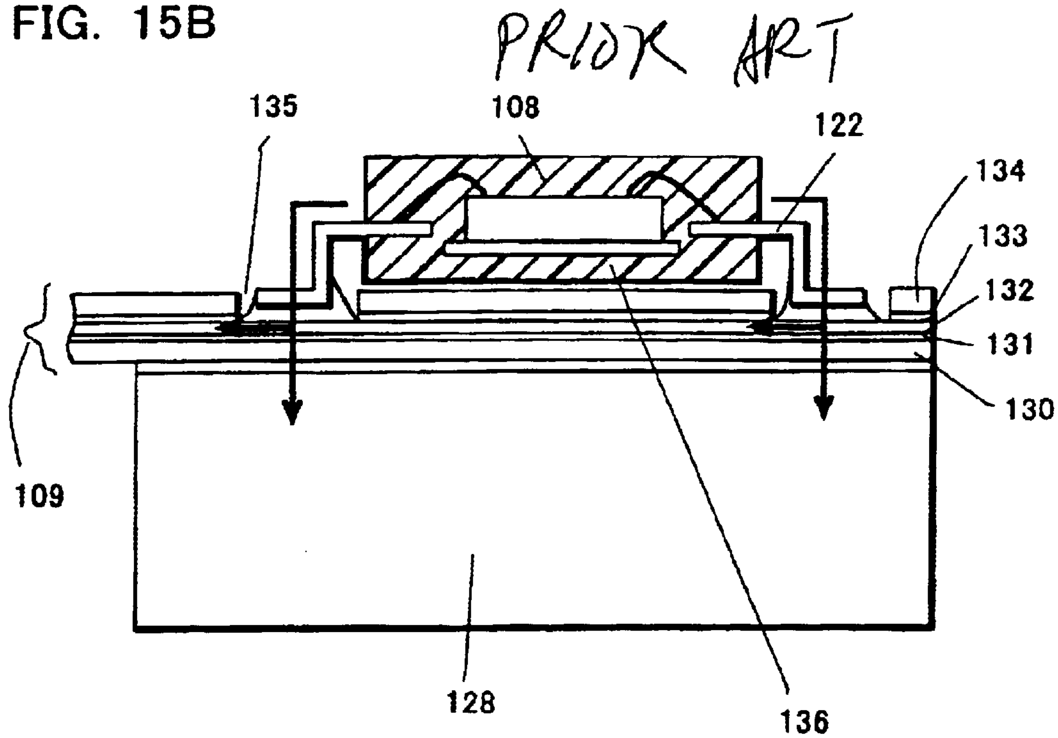


FIG. 15B



SEMICONDUCTOR DEVICE, SEMICONDUCTOR MODULE AND HARD DISK

BACKGROUND OF THE INVENTION

The present invention relates to a semiconductor device, a semiconductor module and a hard disk, and especially to a structure capable of efficiently dissipating heat from a semiconductor chip.

Due to the recent growth of the use of semiconductor devices in portable devices and small/densely-mounted devices, the reduction in size and weight and the improvement in heat dissipation properties are demanded at the same time. In addition, semiconductor devices are mounted on various types of substrates, which, in turn, are mounted in various many systems as semiconductor modules. As for such a substrate, the use of a ceramic substrate, a printed board, a flexible sheet, a metal substrate or a glass substrate etc. may be contemplated, and the following description gives one example thereof. Here, the semiconductor module is explained as being mounted on a flexible sheet.

FIG. **14** shows an example in which a semiconductor module using a flexible sheet is mounted in a hard disk **100**. This hard disk may be, for example, the one described in detail in an article of Nikkei Electronics (No. 691, Jun. 16, 1997, p. 92-).

This hard disk is accommodated within a casing made of a metal, and comprises a plurality of recording disks that are integrally attached to a spindle motor. Over the surfaces of individual recording disks, magnetic heads are respectively disposed each with a very small clearance. These magnetic heads are attached at the tips of suspensions which are affixed to the ends of respective arms. A magnetic head, a suspension and an arm together form one integral body and this integral body is attached to an actuator.

The magnetic heads must be electrically connected with a read/write amplifying IC in order to perform read and write operations. Accordingly, a semiconductor module comprising this read/write amplifying IC mounted on a flexible sheet is used, and the wirings provided on this flexible sheet are electrically connected, ultimately, to the magnetic heads. This semiconductor module is called "flexible circuit assembly", typically abbreviated as "FCA."

From the back surface of the casing, connectors provided on the semiconductor module are exposed, and these connector (male or female) and connectors (female or male) attached on a main board are engaged. On this main board, wirings are provided, and driving ICs for the spindle motor, a buffer memory and other ICs for a driving, such as ASIC, are mounted.

The recording disk spins at, for example, 4500 rpm via the spindle motor, and the actuator detects the position of the magnetic head. Since this spinning mechanism is enclosed by a cover provided over the casing, there is no way to completely prevent the accumulation of heat, resulting in the temperature rise in the read/write amplifying IC. Therefore, the read/write amplifying IC is attached to the actuator or the casing etc. at a location having a better heat dissipation property than elsewhere. Further, since revolutions of the spindle motor tend to high-speed such as 5400, 7200 and 10000 rpm, this heat dissipation has more importance.

In order to provide further detail of the FCA explained above, the structure thereof is shown in FIGS. **15**A and **15**B. FIG. **15**A is the plan view, and FIG. **15**B is a cross-sectional

view taken along the line A—A which cuts across a read/write amplifying IC **115** provided on one end of the module. This FCA **117** is attached to an internal portion of the casing in a folded-state, so that it employs a first flexible sheet **116** have a two-dimensional shape that can easily be folded.

On the left end of this FCA **117**, the connectors **111** are attached, forming a first connection section **120**. First wirings **121** electrically connected to these connectors **111** are adhered on the first flexible sheet **116**, and they extend all the way to the right end. The first wirings **121** are then electrically connected to the read/write amplifying IC **115**. Leads **122** of the read/write amplifying IC **115** to be connected to the magnetic heads are connected with second wirings **123** which, in turn, are electrically connected to third wirings **126** on a second flexible sheet **124** provided over the arm and suspension. That is, the right end of the first flexible sheet **116** forms a second connection section **127** at which the first flexible sheet **116** is connected to the second flexible sheet **124**. Alternatively, the first flexible sheet **116** and the second flexible sheet **124** may be integrally formed. In this case, the second wirings **123** and the third wirings **126** are provided integrally.

On the back surface of the first flexible sheet **116** on which the read/write amplifying IC **115** is to be provided, a supporting member **128** is disposed. As for this supporting member **128**, a ceramic substrate or an Al substrate may be used. The read/write amplifying IC **115** is thermally coupled with a metal that is exposed to inside of the casing through this supporting member **128**, so that the heat generated in the read/write amplifying IC **115** can be externally released.

With reference to FIG. **15**B, a connecting structure between the read/write amplifying IC **115** and the first flexible sheet **116** will now be explained.

This flexible sheet **115** is constituted by laminating, from the bottom, a first polyimide sheet **130** (first PI sheet), a first adhesion layer **131**, a conductive pattern **132**, a second adhesion layer **133** and a second polyimide sheet **134** (second PI sheet), so that the conductive pattern **132** is sandwiched between the first and second PI sheets **130** and **134**.

In order to connect the read/write amplifying IC **115**, a portion of the second PI sheet **134** and the second adhesion layer **133** are eliminated at a desired location to form an opening **135** which exposes the conductive pattern **132**. The read/write amplifying IC **115** is electrically connected thereto through leads **122** as shown in the figure.

The semiconductor device packaged by an insulating resin **136** as shown in FIG. **15**B has heat dissipating paths indicated by arrows for externally dissipating its heat, but there has been a problem in that, due to the thermal resistance given by the insulating resin **136**, the heat generated by the read/write amplifying IC **115** cannot be efficiently dissipated to the outside the device.

Further details will now be explained using this example in hard disk application. As for the read/write transfer rate of a hard disk, a frequency of 500 MHz to 1 GHz, or even a greater frequency, is required, so that the read/write speed of the read/write amplifying IC **115** must be fast. To this end, the paths of the wirings on the flexible sheet that are connected to the read/write amplifying IC **115** has to be reduced, and the temperature rise in the read/write amplifying IC **115** must be suppressed.

Especially, since the recording disks are spinning at a high speed, and the casing and the lid provide a sealed space, the interior temperature would rise up to around 70 to 80° C. On the other hand, a typical allowable temperature for the operation of an IC is approximately 125° C. This means that, from the interior temperature of 80° C., a further temperature rise by approximately 45° C. is permissible for the read/write amplifying IC **115**. However, where the thermal resistance of the semiconductor device itself and FCA is large, this allowable operation temperature can easily be exceeded, thereby disabling the device to provide its actual performance level. Accordingly, a semiconductor device and FCA having superior heat dissipating properties are being demanded.

Furthermore, since the operation frequency is expected to further increase in the future, further temperature rise is also expected in the read/write amplifying IC **115** itself due to the heat generated by computing operations. At room temperature, the IC can provide the performance at its intended operation frequency, however, where it is placed inside of a hard disk, its operation frequency has to be reduced in order to restrain the temperature rise.

As described above, further heat dissipating properties of semiconductor device, semiconductor module (FCA) are demanded in connection with the increase of the operation frequency in the future.

On the other hand, the actuator, and the arms, suspensions and magnetic heads attached thereto has to be designed as light-weighted as possible in order to reduce the moment of inertia. Especially, where the read/write amplifying IC **115** is mounted on the surface of the actuator, the weight reduction is demanded also for the IC **115** and FCA **117**.

SUMMARY OF THE INVENTION

The present invention was invented in consideration with the above problems, and in the first aspect, it provides a semiconductor device comprising a semiconductor chip integrally sealed by an insulating resin, the back surfaces of the semiconductor chip and a metal member having a pad electrically connected to a bonding electrode of the semiconductor chip, being exposed from the back surface of the semiconductor device, wherein the problem is solved by providing a metal plate on the exposed portion of the semiconductor chip in a manner so that the metal plate protrudes beyond the back surface of the metal member.

Since this protrusive metal plate would become within a same plane with the back surface of the flexible sheet which is the first supporting member, the structure allows the metal plate to be adhered or abutted to a heat-dissipating plate which is the second supporting member. Accordingly, the heat from the semiconductor chip can be transmitted to the heat-dissipating plate.

In the second aspect, the problem is solved by disposing the back surface of the metal member and the back surface of the semiconductor chip substantially within a same plane.

In the third aspect, the problem is solved by using the insulating resin to affix the semiconductor chip.

In the fourth aspect, the problem is solved by affixing the back surface of the semiconductor chip and the metal plate together using an insulating material or a conductive material.

In the fifth aspect, the problem is solved by having the back surface of the insulating resin protrude beyond the back surface of the metal member.

In the sixth aspect, the problem is solved by having the side surfaces of the metal member and the back surface of the insulating resin that extends from the side surfaces of the metal member define a same curved surface.

In the seventh aspect, a semiconductor module is provided, which comprises a first supporting member having a conductive pattern provided therein and a semiconductor device comprising a semiconductor chip which is electrically connected to the conductive pattern and is integrally sealed by an insulating resin, the back surfaces of the semiconductor chip and a metal member having a pad electrically connected to a bonding electrode of the semiconductor chip being exposed from the back surface of the semiconductor device, wherein the problem is solved by electrically connecting the metal member to the conductive pattern provided in the first supporting member, and providing an opening to the first supporting member at a location which corresponds to the semiconductor chip, the opening accommodating a metal plate which is affixed to the back surface of the semiconductor chip.

In the eighth aspect, the problem is solved by adhering a second supporting member having the metal plate affixed thereto to the back surface of the first supporting member.

In the ninth aspect, the problem is solved by providing a fixation plate made of a conductive material over the second supporting member at a location which corresponds to the metal plate, and by thermally coupling the fixation plate and the metal plate.

In the tenth aspect, the problem is solved by forming, respectively, the metal plate mainly by Cu, the second supporting member mainly by Al, and the fixation plate by a plated film mainly made of Cu formed on the second supporting member.

In the eleventh aspect, the problem is solved by having the back surface of the insulating resin protrude beyond the back surface of the metal member.

In the twelfth aspect, the problem is solved by having the side surfaces of the metal member and the back surface of the insulating resin which extends from the side surfaces of the metal member define a same curved surface.

In the thirteenth aspect, the problem is solved by using the semiconductor chip as a read/write amplifying IC for a hard disk.

In the fourteenth aspect, a semiconductor device is provided, which comprises a semiconductor chip integrally sealed by an insulating resin, the back surfaces of the semiconductor chip, a metal member having a pad electrically connected to a bonding electrode of the semiconductor chip and an external connection electrode that extends via a wiring integral with the metal member being exposed from the back surface of the semiconductor device, wherein the problem is solved by disposing a metal plate over the back surface of the semiconductor chip in a manner so as that the metal plate protrudes beyond the back surface of the external connection electrode.

In the fifteenth aspect, the problem is solved by disposing the back surface of the external connection electrode and the back surface of the semiconductor chip substantially within a same plane.

In the sixteenth aspect, the problem is solved by affixing the back surface of the semiconductor chip and the metal plate together by an insulating material or a conductive material.

In the seventeenth aspect, the problem is solved by having the back surface of the insulating resin protrude beyond the back surface of the external connection electrode.

In the eighteenth aspect, the problem is solved by having the side surfaces of the external connection electrode and the back surface of the insulating resin extending from the side surfaces of the external connection electrode define a same curved surface.

In the nineteenth aspect, a semiconductor module is provided, which comprises a first supporting member having a conductive pattern provided therein and a semiconductor device comprising a semiconductor chip which is electrically connected to the conductive pattern and is integrally sealed by an insulating resin, the back surfaces of the semiconductor chip, a metal member having a pad electrically connected to a bonding electrode of the semiconductor chip and an external connection electrode provided via a wiring which is integral with the metal member being exposed from the back surface of the semiconductor device, wherein the problem is solved by electrically connecting the conductive pattern provided in the first supporting member to the external connection electrode, and providing an opening in the first supporting member at a location corresponding to the semiconductor chip, the opening accommodating a metal plate affixed to the back surface of the semiconductor chip.

In the twentieth aspect, the problem is solved by adhering a second supporting member having the metal plate affixed thereto to the back surface of the first supporting member.

In the twenty-first aspect, the problem is solved by forming the external connection electrode and the metal plate integrally from a same material.

In the twenty-second aspect, the problem is solved by providing a fixation plate made of a conductive material to the second supporting member at a location corresponding to the metal plate, and by thermally coupling the fixation plate and the metal plate.

In the twenty-third aspect, the problem is solved by forming, respectively, the metal plate mainly by Cu, the second supporting member mainly by Al and the fixation plate by a plated film mainly made of Cu formed on the second supporting member.

In the twenty-fourth aspect, the problem is solved by having the back surface of the insulating adhesive means protrude beyond the back surface of the external connection electrode.

In the twenty-fifth aspect, the problem is solved by having the side surfaces of the external connection electrode and the back surface of the insulating adhesive means extending from the external connection electrode define a same curved surface.

In the twenty-sixth aspect, the problem is solved by using the semiconductor chip as a read/write amplifying IC for a hard disk.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are diagrams illustrating a semiconductor module according to the present invention.

FIGS. **2**A and **2**B are diagrams illustrating a semiconductor device according to the present invention.

FIGS. **3**A and **3**B are diagrams illustrating a semiconductor device according to the present invention.

FIG. **4** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **5** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **6** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **7** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **8** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **9** is a diagram illustrating a semiconductor module of the present invention.

FIG. **10** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **11** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIG. **12** is a diagram illustrating a manufacturing step of a semiconductor device according to the present invention.

FIGS. **13**A and **13**B are diagrams illustrating a semiconductor device according to the present invention.

FIG. **14** is a diagram illustrating a hard disk.

FIGS. **15**A and **15**B are diagrams illustrating a conventional art semiconductor module.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention provides a thin and small semiconductor device having a superior heat-dissipating capability, and a semiconductor module having this semiconductor device mounted, such as a semiconductor module mounted on a flexible sheet (hereinafter referred to as "FCA"), thereby improving the characteristics of, for example, a hard disk.

First, reference shall be made to FIG. **14** illustrating an exemplary hard disk **100** in which an FCA **50** is implemented, and then to FIG. **1**A showing the FCA **50**. A semiconductor device mounted on this FCA **50** and the manufacturing method thereof are shown in FIGS. **2** through **13**.

Embodiment 1

The first embodiment is provided to illustrate an apparatus in which the FCA **50** is implemented. As for this apparatus, the exemplary hard disk **100** that has been used for illustrating the conventional art will be used again.

The hard disk **100** may be mounted on a main board **112** as necessary in order to place it in a computer etc. This main board **112** includes female (or male) connectors. Male (or female) connectors **111** provided on the FCA **50** and exposed from the back surface of the casing **101** are connected with these connectors on the main board **112**. Within the casing **101**, a plurality of recording disks **102** used as a recording medium are provided in a number corresponding to the storage capacity of the hard disk. Since each of the magnetic heads **104** floats and scans over each of the recording disks **102** at a position approximately 20 nm to 30 nm away from the disk, the interval between the recording disks **102** are designed so as to allow this scanning to be undisturbed. The disks are retained at this interval and attached to a spindle motor **103**. This spindle motor **103** is mounted on a mounting board, and a connector arranged on the back surface of this mounting board is exposed from the back surface of the casing **101**. This connector is connected to a connector of the main board. Accordingly, mounted on this main board **112** are, a read/write amplifying IC, an IC for driving the read/write amplifying IC for magnetic heads **104** to which a suspension **106** is connected, an IC for driving the spindle motor **103**, an IC for driving an actuator, a buffer memory for temporarily storing data, and other ASICs etc. for implementing the manufacturer's own driving scheme. Of course, any additional active and passive elements may also be mounted.

The wirings connecting between the magnetic heads **104** and the read/write amplifying IC are designed to be as short as possible, so that the read/write amplifying IC is disposed on the actuator **107**. Since a semiconductor device **10**A of the present invention is extremely thin, it may be attached to the actuator **107** or instead be mounted on the arm **105**. As shown in FIG. **1**B, the back surface of the semiconductor device **10**A is exposed from the opening **12** of the first supporting member **11** and thermally coupled to the arm **105**, so that the heat from the semiconductor device **10**A is externally dissipated via the arm **105** and the casing **101**. Since in this example, an application to a hard disk is assumed, a flexible sheet **109** has been selected for the use as the first supporting member **11**, however, depending on the types of the apparatus, a printed board or a ceramic substrate etc. may instead be selected as the first supporting member **11**.

Also, herein, Au or a brazing material such as solder is applied to the back surface of the semiconductor chip **16** in order to affix a metal plate **23** to the back surface of the semiconductor chip **16**.

Embodiment 2

The semiconductor device according to the second embodiment of the present invention will now be explained with reference to FIGS. **2**A and **2**B. FIG. **2**A is a plan view of the semiconductor device, and FIG. **2**B is a cross-sectional view taken along the ling A—A.

In FIG. **2**A, the following elements are shown as embedded within an insulating resin **13**; bonding metal members **14** and a semiconductor chip **16** disposed over the region surrounded by the bonding metal members **14**. As apparent from the manufacturing step shown in FIG. **7**, the semiconductor chip **16** is affixed within an isolation trench **22** via a brazing material or a conductive paste etc. It may alternatively be affixed by an insulating adhesive means.

The bonding electrodes **19** of the semiconductor chip **16** and the bonding metal members **14** are electrically connected via thin metal lines **20**.

The back surfaces of the bonding metal members **14** are exposed from the insulating resin **13**, and as they are, form external connection electrodes **21**, and the side surfaces of the bonding metal members **14** are etched non-anisotropically. These etched portions are formed by a wet etching method, so that they have a curved structure which promotes an anchor effect.

This structure is formed by three elements including the semiconductor chip **16**, a plurality of metal members **14**, the insulating resin **13** within which the former two are embedded. Within a region for disposing the semiconductor chip **16**, the back surface of the semiconductor device **10**A is exposed. All the elements including the above are sealed within the insulating resin **13**. The bonding metal members **14** and the semiconductor chip **16** are supported by this insulating resin **13**.

As for the insulating resin **13**, a heat-curable resin such as epoxy resin, or a thermoplastic resin such as polyimide resin or polyphenylene sulfide etc. may be used.

Any resin material can be used as the insulating resin as long as it can be cured within a metal mold, or can be applied by dipping or coating. For the metal member **14**, a conductive foil mainly made of Cu, a conductive foil mainly made of Al or an Fe—Ni alloy, a laminate of Al—Cu or a laminate of Al—Cu—Al or the like may be used. Of course other conductive material may also be used, and especially desirable are those conductive materials that can be etched, or that can be evaporated by laser. When the half-etching, plating and thermal stress characteristics are concerned, a conductive material mainly made of Cu formed through rolling is suitable.

According to the present invention, the trench **22** is also filled with the insulating resin **13** so that slipping-out of the metal member **14** may be prevented. Also, by performing non-anisotropic etching through a dry-etch or wet-etch method, the side surfaces of the bonding metal members **14** may be processed to have a curved structure thereby promoting the anchor effect, which in turn realizes a structure that would not allow the metal member **14** to slip out from the insulating resin **13**.

Moreover, the back surface of the semiconductor chip **16** is exposed from the back surface of the package. Therefore, the back surface of the semiconductor chip **16** would form a structure that can be abutted or attached to the later-described metal plate **23**, the second supporting member **24** or a fixation plate **25** formed on the second supporting member **24**. Accordingly, this structure allows the heat generated by the semiconductor chip **16** to be dissipated into the second supporting member **24**, thereby preventing the temperature rise of the semiconductor chip **16** so that the driving current and driving frequency of the semiconductor chip **16** may be increased.

In the semiconductor device **10**A, since the metal member **14** is supported by the insulating resin **13**, which is a sealant, the use of any supporting substrate is made unnecessary. This structure is one feature of the present invention. The conductive paths of the conventional art semiconductor device are supported by a supporting substrate (flexible sheet, printed board or ceramic substrate), or by a lead frame, and this means that the conventional art device includes those elements that could potentially be made unnecessary. On the other hand, the device of the present invention is constituted by only essential, minimal elements, and it eliminates the need for a supporting substrate, thus it can be made thin and light-weighted, and at the same time, its cost may be reduced as it requires less material cost.

On the back surface of the package (semiconductor device **10**A), an insulating film **26** is formed in order to allow a film of the brazing material to be provided in a uniform thickness. The regions surrounded by dotted lines **27** shown in FIG. **2**A indicate the portions of the semiconductor chip **16** exposed from the insulating film **26**, and these portions are exposed in the same manner as the exposed square-shaped portions of the back surfaces of the bonding metal members **14**, the individual potions of the semiconductor chip **16** exposed from the insulating film **26** and the exposed portions of the bonding metal members **14** have the same size.

Thus, the sizes of the portions wettable by the brazing material are substantially identical so that the brazing material formed thereto would have substantially the same thickness. This would not change even after a solder print or reflow process.

The same is true for a conductive paste of i.e. Ag, Au or Ag—Pd etc. Given this structure, more accurate calculation can be performed to determine how much the back surface of the metal plate should protrude beyond the back surfaces of the bonding metal members **14**. Where solder balls are formed as shown in FIG. **2**B, the bottom ends of the solder balls may be abutted to conductive paths of the mounting board, so that soldering failure may be eliminated.

The exposed portions **27** of the back surface of the semiconductor chip **16** may be formed to have a larger size than that of the exposed portions of the bonding metal member in consideration with the dissipation capability of the heat from the semiconductor chip.

The provision of the insulating film **26** also allows the conductive pattern **32** provided on the first supporting member **11** to be disposed over the back surface of the semiconductor device. Generally, the conductive pattern **32** provided in the first supporting member **11** is so arranged that it bypasses the region in which the semiconductor device is attached, however, the provision of the insulating film **26** allows it to be disposed without such bypassing. In addition, since the insulating resin **13** protrudes beyond the conductive pattern, a gap may be formed between the wirings on the first supporting member **11** and the conductive pattern, thereby enabling to prevent short-circuiting.

Embodiment 3

FIGS. **3**A and **3**B show another semiconductor device **10**B according to the present invention. FIG. **3**A is a plan view thereof, and FIG. **3**B is a cross-sectional view taken along the line A—A. Since this structure is similar to that of FIGS. **2**A and **2**B, the following provides only the description pertinent to those features that are different from the device in FIGS. **2**A and **2**B.

In FIG. **2**B, the back surfaces of the bonding metal members **14** are used as the external connection electrodes as they are, however, in this embodiment, a wiring **30** and an external connection electrode **31** integrally formed with the wiring **30** are provided to each of the bonding metal members **14**.

The rectangle shown by a dotted line represents the semiconductor chip **16**, and on the back surface of the semiconductor chip **10**B, the external connection electrodes **31** are disposed in a ring-like arrangement as shown, or in a matrix. This arrangement is identical or similar to that of known BGA. The wirings **30** may be formed in a wavy shape with respect to the distortion at the bonding portion.

The locations at which the device is connected with the conductive pattern **32** of the first supporting member **11** would be the external connection electrodes **31**, and the back surfaces of the bonding metal members **14** and the lines **30** are covered by the insulating film **26**. The dotted circles indicated in the regions of the external connection electrodes **31** and the semiconductor chip **16** represent the portions that expose from the insulating film **26**.

Furthermore, since the semiconductor chip **16** is provided within the inner side of the external connection electrodes **31**, this semiconductor chip is designed to be smaller than the semiconductor chip shown in FIGS. **2**A and **2**B. Accordingly, the insulating resin **13** covers the bonding metal members **14** and wirings **30**, the semiconductor chip **16** and the metal thin lines **20**.

The present embodiment has an advantage in that, even when the number of the bonding metal members **14** is extremely large and their size has to be reduced, the size of the external connection electrodes **31** may be made sufficiently large by connecting them via the wirings and rearranging them as the external connection electrodes. The presence of the wirings also alleviates the distortion stress applied to the connections of the metal thin lines and the connections of solder.

According to this embodiment, the back surface of the semiconductor chip **16** is entirely exposed as shown in FIGS. **3**A and **3**B, however, the back surface of the semiconductor chip **16** can be covered with the insulating film **26** and exposed from the insulating film **26** at the (square-shaped or circle-shaped) exposed portions as described in the second embodiment and shown in FIGS. **2**A and **2**B.

Embodiment 4

The fourth embodiment explains a manufacturing method of the semiconductor devices **10**A and **10**B. Herein, the semiconductor device **10**B in FIG. **3**B is used to illustrate the manufacturing method. FIGS. **4** through **8** are the cross-sectional views of FIG. **3**A taken along the line A—A.

First, as shown in FIG. **4**, a conductive toil is provided. The thickness of the foil is desirably between 10 μm and 300 μm, and herein, a rolled copper foil in a thickness of 70 μm is used. Next, over the surface of this conductive foil **40**, a conductive film **41** or a photo resist is formed as an etching mask. This pattern is identical to the patterns of the bonding metal members **14**, wirings **30** and external connection electrodes **31** of FIG. **3**A. Where a photo resist is used instead of the conductive film **41**, a conductive film of Au, Ag, Pd, Ni or the like should be provided under the photo resist at least over the portions corresponding to the bonding metal members. This film is provided to enable the bonding. (FIG. **4**).

Thereafter, the conductive foil **40** is half-etched via the conductive film **41** or the photo resist. The depth of etching may be arbitrary so long as that it is shallower than the thickness of the conductive foil **40**. A shallower etching depth allows the formation of a finer pattern.

By this half-etching, convex metal members of **14**, **30** and **31** manifest on the surface of the conductive foil **40**. The conductive foil **40** used herein is a Cu foil mainly made of Cu, which has been formed by rolling as priorly mentioned. However, it may also be a conductive foil made of Al or an Fe—Ni alloy, or a laminate of Cu—Al or Al—Cu—Al. The laminate of Al—Cu—Al, especially, can prevent warping caused by a difference in thermal expansion coefficients.

An adhesive means **17** is then provided on the bottom of the isolation trench **22** which has been formed in the region surrounded by the external connection electrodes **31**. The attachment of the semiconductor chip may be achieved via the conductive foil, the brazing material and the conductive paste, by forming a conductive film such as the one made of Au etc. over the back surface of the semiconductor chip. In this case, a brazing material such as solder etc. or bumps may be formed as shown in FIG. **3**B. However, where this attachment is obtained through an insulating adhesive, then the formation of the brazing material such as solder etc. or bumps would be more difficult. (FIG. **5**).

The semiconductor chip **16** is then affixed to the region in which the adhesive means **17** has been provided, and the bonding electrodes **19** of the semiconductor chip **16** and the bonding metal members **14** are electrically connected. In the embodiment shown in the diagrams, since the semiconductor chip **16** is mounted with its face up, the metal thin lines **20** are used as the connecting means.

In this bonding process, since the bonding metal members **14** are integral with the conductive foil **40**, and the back surface of the conductive foil **40** is flat, it can be abutted to the table of the bonding machine by the plane. Accordingly, if the conductive foil **40** is perfectly fixed to the bonding table, misalignment of the bonding metal members **14** would not occur, thus the bonding energy can be efficiently transmitted to the metal thin lines **20** and the bonding metal members **14**. This allows the connections of the metal thin lines **20** to have improved attachment strength. The fixation to the bonding table may be achieved by, for example, providing a plurality of vacuum holes over the entire surface of the table. Alternatively, the conductive foil **40** may be pressed from the above.

The semiconductor chip may be mounted without using a supporting substrate, and it may be affixed onto the bottom of the isolation trench **22**, therefore the semiconductor chip **16** may be disposed at a position lower by that extent.

Accordingly, the outer thickness of the package may be reduced as later explained. (FIG. **6**).

The insulating resin **13** is then formed so as to cover the bonding metal members **14**, the wirings **30**, and the external connection electrodes **31** formed via the half-etching, and the semiconductor chip **16** and the metal thin lines **20**. For the insulating resin, either a thermoplastic resin or a heat-curable resin may be used.

It may be formed via transfer molding, injection molding, dipping or coating. For a heat-curable resin such as epoxy resin, transfer molding may be employed, and for a thermoplastic resin such as liquid crystal polymer or polyphenylene sulfide etc., injection molding may be employed.

In the present embodiment, the thickness of the insulating resin is adjusted so that its top end comes at approximately 100 μm from the top portions of the metal thin lines **20**. This thickness may be made larger or smaller depending on the desired strength of the semiconductor device.

Since the bonding metal members **14**, wirings **30** and the external connection electrodes **31** are all integral with the conductive foil **40** that is in a form of a sheet, these copper foil patterns would never be displaced during the resin injection step as long as the conductive foil **40** itself is not displaced.

As explained in the above, within the insulating resin **13**, the bonding metal members **14**, wirings **30** and external connection electrodes **31** that are formed to be convex features are embedded along with the semiconductor chip **16**, and the portion of the conductive foil **40** below its convex features is exposed from the back surface. (FIG. **7**).

Thereafter, the portion of the conductive foil **40** exposed on the back surface of the insulating resin **13** is eliminated, thereby separating the bonding metal members **14**, wirings **30** and external electrodes **31** into individual elements.

For this separation step, various approaches may be contemplated. For example, they may be separated by etching the back surface, or by polishing or grinding, or even by the combination thereof. For example, where the grinding is performed until the insulating resin **13** is exposed, there is a risk of having residues or stretched metal particles from the ground conductive foil **40** encroach into the insulating resin **13**. Accordingly, by using an etching approach, the separation may be achieved without having the metal residues from the conductive foil **40** encroach into the surface of the insulating resin **13** located between the Cu patterns. In this way, short-circuiting between the patterns that are arranged at fine intervals may be prevented.

In a case where a plurality of units, each comprising a single semiconductor device **10**B, are integrally formed, a dicing step is additionally performed after this separation step.

Although a dicing apparatus is used herein to individually separate the units, it is also possible to perform this step by chocolate-bar-breaking, pressing or cutting.

According to this embodiment, after separating the Cu patterns, an insulating film **26** is formed over the patterns for **14**, **30** and **31** that are isolated and exposed from the back surface, and the insulating film **26** is then patterned so as to expose the portions indicated by the dotted circles shown in FIG. **3**A. Thereafter, it is diced at the sections indicated by arrows into individual semiconductor devices **10**B.

The solder balls **42** may be formed either before or after the dicing step.

According to the manufacturing method above, a thin and small package is fabricated, in which the bonding metal members, wirings, external connection electrodes and a semiconductor chip are embedded within the insulating resin.

The effects obtained by the above manufacturing method will now be explained in the following section.

First, since the metal members are half-etched and supported integrally with the conductive foil, a substrate that has been conventionally employed for supporting is made unnecessary.

Second, since the convex metal members are formed by half-etching the conductive foil, it is possible to form finer metal members. Accordingly, their widths and intervals may be minimized, allowing the formation of a package having a smaller two-dimensional size.

Third, since the device may be constituted by metal members, a semiconductor chip, connection means and a sealing material, the structure would include only the elements that are truly essential, eliminating the excessive use of materials, thus, a thin and small semiconductor device may be realized with a substantially reduced cost.

Fourth, since the bonding metal members, wirings and external connection electrodes are formed as convex portions through half-etching, and the separation to individual elements is performed after the sealing step, tie-bars and suspension leads would not be necessary. Accordingly, the necessity for the formation of tie-bars (suspension leads), and cutting step of the tie-bars (suspension leads) are completely eliminated in the present invention.

Fifth, since the conductive foil is eliminated from the back surface of the insulating resin to separate the metal members after the convex metal members are embedded within the insulating resin, flashes of the resin formed between leads as those present in the conventional lead frames can be eliminated.

Sixth, since the semiconductor chip is exposed from the back surface, the heat generated by the semiconductor device can be dissipated efficiently from the back surface of the semiconductor device.

Embodiment 5

The fifth embodiment is provided for illustrating a semiconductor device **10**A, **10**B to which a metal plate **23** is affixed and a semiconductor module using the same. FIG. **1**A shows this type of semiconductor module (FCA) **50**. The semiconductor device mounted thereto is the semiconductor device **10**A shown in FIGS. **2**A and **2**B.

First, a first supporting member **11** constituted by a flexible sheet will be explained. In the present embodiment, it comprises a first PI sheet **51**, a first adhesion layer **52**, a conductive pattern **53**, a second adhesion layer **54** and a second PI sheet **55** that are sequentially laminated from the bottom. When forming the conductive pattern in multiple layers, additional adhesion layers may be used, and upper and lower layers of the conductive pattern may be electrically connected through contact holes. Provided in this first supporting member **11** is a first opening **12** which would allow at least a metal plate **23** to be exposed as shown in FIG. **1**C.

A second opening **56** is also formed in order to expose the conductive pattern. The second opening **56** may entirely expose the corresponding conductive pattern **32**, or may partially expose only the portion for forming connections. For example, the second PI sheet **55** and the second adhesion layer **54** may entirely be eliminated, or, as shown in the figure, while entirely eliminating the second PI sheet **55**, the second adhesion layer **54** may partially be eliminated only at the locations required to be exposed. According to the later manner, running of the solder **27** may be prevented.

In the semiconductor device of the present invention, a metal plate **23** is adhered to the back surface of the semiconductor chip **16**. In the semiconductor module of the present invention, the back surface of the first supporting member and the metal plate **23** would become substantially within a same plane.

The thickness of the metal plate **23** is determined according to the thicknesses of the first supporting member **11** and the fixation plate **25**. The thicknesses of the respective elements are determined in a manner so that the metal plate **23** exposed from the first opening **12** can be substantially within a same plane with the back surface of the first supporting member **11** when the bonding metal members **14** and the conductive pattern **32** are affixed together through the solder balls **27**. Accordingly, the metal plate **23** may be abutted to the second supporting member or abutted and adhered to the fixation plate **25** provided on the second supporting member.

Several examples of this connection structure are given below.

In the first example of the structure, a light-weight metal plate such as the one made of Al or stainless steel etc., or a ceramic substrate is used as the second supporting member **24**, and the metal plate **23** which has been affixed on the back surface of the semiconductor device **10**A is abutted thereto. That is, in this structure, the abutment to the second supporting member **24** is provided without the use of the fixation plate **25**. The fixation between the semiconductor chip **16** and the metal plate **23**, and between the metal plate **23** and the second supporting member **24** is achieved by a brazing material such as solder etc. or an insulating adhesive means containing fillers having a good thermal conductivity.

In the second example, the structure employs a light-weight metal plate such as the one made of Al or stainless steel etc. or a ceramic substrate as for the second supporting member **24**, and a fixation plate **25** is formed thereon, and this fixation plate **25** and the metal plate **23** are affixed together.

Where an Al plate is used as the second supporting member **24** for example, the fixation plate **25** is preferably the one made of Cu. This is because Cu can be plated over Al to form a Cu film in a thickness up to about 10 μm. In addition, since it is a plated film, it may be formed in intimate contact with the second supporting member **24**, making the thermal resistance between the fixation plate **25** and the second supporting member **24** extremely small.

Alternatively, the Cu fixation plate **25** and the Al substrate may be adhered using an adhesive, however, in this case the thermal resistance would become larger.

Where a ceramic substrate is used as the second supporting member **24**, the fixation plate **25** is attached on an electrode formed by print-baking a conductive paste.

The second supporting member **24** and the first supporting member **11** are adhered together via a third adhesion layer **57**.

For instance;

First PI sheet **51**: 25 μm

Second PI sheet **55**: 25 μm

First and second adhesion layers **52** and **54**: 25 μm after being baked (an acrylic adhesive is used)

Solders **27**: 50 μm;

Third adhesion layer **57**: 25 μm (an acrylic adhesive is used);

Where the thicknesses of the respective layers are adjusted and determined in this way, even if the second supporting member **24** having the fixation plate **25** formed thereon is adhered onto the first supporting member **11** after affixing the semiconductor device **10**A to the first supporting member **11**, the metal plate may be abutted to the fixation plate, so that the connection failure would not occur.

Where a module is provided, in which the second supporting member **24** is attached to the first supporting member **11**, and the semiconductor device **10** is placed within an opening **56** provided in this module and then soldered, the soldering may be performed at once without promoting connection failures.

Accordingly, the heat generated by the semiconductor chip **16** may be dissipated into the second supporting member **24** via the metal plate **23** and the fixation plate **25**. Moreover, since it provides a substantial reduction in the thermal resistance compared to that of the conventional art structure (FIG. **15**B), the driving current and the driving frequency of the semiconductor chip **16** can be maximized. The back surface of this second supporting member **24** may be attached to the actuator **107**, bottom of the casing **101** or the arm **105** shown in FIG. **14**. Therefore, the heat from the semiconductor chip can ultimately be emitted to the outside via the casing **101**. Accordingly, even if the semiconductor module is mounted in the hard disk **100**, the temperature of the semiconductor chip itself is kept relatively low, so that the read/write speed of the hard disk **100** can be further accelerated. This FCA may be mounted on an apparatus other than a hard disk. In this case, the second supporting member should be abutted to a member of the apparatus having a small thermal resistance.

Embodiment 6

The sixth embodiment is provided to illustrate a semiconductor device **10**C in which the metal plate **23** and the bonding metal members are formed from a same material, and a semiconductor module **50**A using the same. First, the manufacturing method thereof will be explained with reference to FIGS. **10** and **11**. Its manufacturing steps corresponding to the steps illustrated in FIGS. **4** through **7** are identical and the descriptions for these steps would not be repeated.

FIG. **10** is showing the conductive foil **40** being covered by the insulating resin **13**, and on the portion corresponding to the metal plate **23**, a photo resist PR is formed. When this conductive foil **40** is etched via the photoresist PR, the resultant metal plate **23** would have a structure which protrudes beyond the back surfaces of the bonding metal members **14**. Alternatively, a conductive film made of Ag or Au etc. may be selectively formed and used as a mask instead of the photo resist PR. This film would function also as an anti-oxidizing film.

In the structure such as the one shown in FIG. **1**B in which the metal plate **23** is adhered, since the metal plate **23** is extremely thin (i.e. 125 μm), the workability is extremely poor. On the other hand, where the metal plate **23** is formed through etching as the protrusive structure, the attaching step of the metal plate **23** may be eliminated.

Next, as shown in FIG. **12**, after the bonding metal members **14**, wirings **30** and external connection electrodes **31** are completely separated, the insulating film **26** is formed, and the portions for forming solder balls **21** are exposed. After the solder balls **21** are provided, it is diced at the sections indicated by arrows.

The isolated semiconductor device is then mounted on the first supporting member **11** as shown in FIG. **9**. Thereafter, the second supporting member **24** is attached thereto as previously mentioned. At this point, since the metal plate **23** is protrusive, it can be readily connected to the fixation plate **25** via soldering etc.

Embodiment 7

The seventh embodiment is provided to illustrate another semiconductor device. FIG. **13**A shows a plan view of the semiconductor device according to the present invention, and FIG. **13**B shows a cross-sectional view of FIG. **13**A taken along the line A—A.

According to the present embodiment, semiconductor chips **16**A and **16**B are packaged, and at the peripheries of these semiconductor chips, bonding metal members **14** are provided. The back surfaces of these bonding metal members themselves serve as the external connection electrodes, however, the re-arranged type of wirings shown in FIGS. **3**A and **3**B may instead be employed. Between the first and second semiconductor chips **16**A and **16**B, at least one bridge **71** is disposed.

The first semiconductor chip **16**A and the second semiconductor chip **16**B are connected via metal thin lines **20**.

The metal thin lines include a first set of metal thin lines **20**A that are connected to the bonding metal members **14** and a second set of metal thin lines **20**B that are connected to the bridges **71**. A plurality of bonding electrodes **19** are provided on the semiconductor chips. According to I/O signals to and from the bonding electrodes **19**, at least a part of the bonding electrode **19** are selected, and the locations and count of the bonding metal members **14** are determined correspondingly. The selected bonding electrodes **19** on the semiconductor chips and the bonding metal members **14** are connected via the first set of metal thin lines **20**A.

On the other hand, the connection between the first and second semiconductor chips **16**A and **16**B is provided by the second set of metal thin lines **20**B connecting between the bonding electrodes **19** on the first semiconductor chip **16**A and one ends of the bridges **71**, and between the other ends of the bridges **71** and the bonding electrodes **19** on the second semiconductor chip **16**B.

Since the bridges **71** are provided in the present structure, the ends of the metal thin lines connected on the side of the first and second semiconductor chips **16**A and **16**B may all be connected by ball bonding.

As apparent from the manufacturing method previously explained, by half-etching the conductive foil, and performing the molding of the insulating resin **13** before it is completely isolated, the risk of having the bridges **71** fall down or slip out may be eliminated.

According to the present invention, a plurality of chips may be packaged into a single package as this embodiment.

The embodiments described heretofore are provided in order to illustrate the structures designed in consideration with the heat-dissipating capability of a single read/write amplifying IC. However, where the applications to various types of apparatus are contemplated, there may be a case in which the heat-dissipating capability of a plurality of semiconductor chips must be considered. Of course, it is possible to package them into separate, individual packages, however, the plurality of the semiconductor chips may also be packaged into one package as illustrated in FIGS. **13**A and **13**B.

The metal plates may of course be connected to the semiconductor chips as shown in FIG. **1**B, and these may be mounted on a flexible sheet or a flexible sheet having the second supporting member attached thereon.

The embodiments described above are explained with a flexible sheet as a substrate, however, a ceramic substrate, a printed board, a flexible sheet, a metal substrate or a glass substrate etc. can also be applied to the substrate of the present invention.

As apparent from the above description, according to the present invention, a metal plate is affixed to a semiconductor chip exposed from the back surface of a package to provide a semiconductor device in which the metal plate protrudes beyond the back surfaces of external connection electrodes or the bonding metal members, thereby facilitating the mounting of the device on an FCA.

Especially, by providing an opening to the FCA so as to allow the back surface of the FCA to be within a same plane with the back surface of the semiconductor chip, the abutment to the second supporting member can be readily achieved.

By using Al as for the second supporting member material and by forming thereon a fixation plate made of Cu, and affixing the metal plate to this fixation plate, the heat generated by the semiconductor chip may be externally dissipated via the second supporting member.

Accordingly, the temperature rise of the semiconductor chip may be prevented, allowing the device to operate at a higher performance level close to its inherent capability. Especially, such an FCA used in a hard disk is capable of providing efficient external emission of heat so that the read/write speed of the hard disk may be increased.

What is claimed is:

1. A semiconductor module comprising:

a semiconductor device including:

a semiconductor chip integrally sealed in an insulating resin but having a back surface exposed and free from the insulating resin;

a metal member sealed in the insulating resin with the semiconductor chip, the metal member having a top surface on which a pad is electrically connected to a bonding electrode of the semiconductor chip, side surfaces that are curved, and a back surface that is exposed and free from the insulating resin;

a first supporting member having a conductive pattern provided therein, said conductive pattern being partially exposed to connect electrically to the exposed back surface of the metal member, and said first supporting member having an opening at a location corresponding to the semiconductor chip;

a metal plate provided on the back surface of the semiconductor chip in the opening; and

a second supporting member having the metal plate affixed thereto is adhered onto the back surface of the first supporting member;

wherein a fixation plate made of a conductive material is provided on the second supporting member at a location corresponding to the metal plate, the fixation plate and the metal plate thermally coupled, and the metal plate is mainly made of Cu, the second supporting member is mainly made of Al, and the fixation plate is constituted by a plated film mainly made of Cu formed on the second supporting member.

2. A semiconductor module as claimed in claim **1** wherein the back surface of the insulating resin protrudes beyond the back surface of the metal member.

3. A semiconductor module as claimed in claim **1**, wherein the semiconductor chip is a read/write amplifying IC for a hard disk.

4. A semiconductor module comprising:

a semiconductor device including:

a semiconductor chip integrally sealed in an insulating resin but exposed and free from the insulating resin at a semiconductor chip's back surface;

an external connection electrode integrally sealed in the insulating resin with the semiconductor chip, said external connection electrode having a top surface on which a pad is electrically connected to a bonding electrode of the semiconductor chip and on which a wiring extends from the pad, side surfaces that are curved, and a back surface that is exposed and free from the insulating resin;

a first supporting member having a conductive pattern provided therein, said conductive pattern being partially exposed to couple electrically to the exposed back surface of the external connection electrode, said first supporting member having an opening at a location corresponding to the semiconductor chip;

a metal plate affixed to the semiconductor chip through the opening; and

a second supporting member having the metal plate affixed thereto and adhered onto the back surface of the first supporting member;

wherein a fixation plate made of a conductive material is provided on the second supporting member at a location corresponding to the metal plate, the fixation plate and the metal plate thermally coupled and the metal plate is mainly made of Cu, the second supporting member is mainly made of Al, and the fixation plate is constituted by a plated film mainly made of Cu formed on the second supporting member.

5. A semiconductor module as claimed in claim **4**, wherein the external connection electrode and the metal plate are integrally formed from a same material.

6. A semiconductor module as claimed in claim **4**, wherein the back surface of the insulating resin protrudes beyond the back surface of the external connection electrode.

7. A semiconductor module as claimed in claim **4**, wherein the semiconductor chip is a read/write amplifying IC for a hard disk.

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